Evaluating crop simulation models using different fertility sources and climate model outputs to improve the productivity of sorghum

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Outcome no.1 _ _	Output no. 1_1	Activity no.1_1_1_3
Sub-activity title	**MA1112-18: Evaluating crop simulation models using different fertility sources and climate model outputs to improve the productivity of sorghum**	
Location/sites for sub-activity	Koutiala, Bougouni and Bamako, Mali	
Implementation timeframe (start/end date)	**July, 2018 –March,2020**	
Deliverables	1. Best fertilizer management practices that will contribute to increased sorghum productivity 2. At least 300 farmers will be reached via farmers field day on fertility micro-dosing technology 3. Crop simulation Models (DSSAT and APSIM) outputs under different fertilizer scenarios to future climatic condition 4. Economic cost and benefit analysis of sorghum under different fertilizer management application performed	4. Paper on Improving grain sorghum productivity in water-limited environments under climate change peer reviewed journal 5. Technology 3: Sorghum-NPK-organic manure; Mali. Chapter 3: Integrated soil fertility management 6. The field trial will contributions to capacity building of PhD student research objectives
S.I. domain and indicators for which data was collected – indicate metric and scale	1. Productivity: Kg biomass (yield, fodder)/ha/season, coefficient of variability, distribution, etc. Number of crops grown per year on a given plot (by crop), Plant population density (seeds/ha/season or seeds/ha/year) at plot level 2. Environmental (soil fertility, NPK, pH, OM at plot level)	3.Economics: Net income, profitability 4. Ranking of technologies /treatments locally will be determined during farmers field and also analytical and modelling approaches at plot level
Contributors	Birhanu Zemadim,**Akinseye Folorunso Mathew,** Bouba Traore, Felix Badolo, Karamoko Traore, Mahamadou Dicko and Madina Diacoumba (ICRISAT), Oumar Samake(AMEDD)	
Farming systems research perspective (how this work links with others)	1. Three different agro-ecologies across rainfall gradient 2. Different fertilizer sources and contrasted sorghum varieties as an options 3. Climate forecasting: seasonal rainfall, onset of growing season , length of growing season and forecasting temperature	

2. Objectives: **To optimize nutrient flow under different soil fertility management for sorghum productivity**

2.1 To better understand physiological functioning and yield productivity of sorghums under different fertilizer management (livestock manure and inorganic fertilizer) across different rainfall gradients and soil characterizations

2.2 Evaluates the productivity of sorghum using the validated crop simulation models (APSIM and DSSAT) under current and future climate conditions based on observations and on Global Climate Models (GCMs) output

2.3. Determine the marginal cost benefit responses of different fertilizer sources based on current farming management practices and prevailing market.

Experimental design and Treatment

Split-plot design- Main plot : Sorghum variety includes three sorghum varieties**: Fadda (improved hybrid), Soumba, Tieble (CSM335)**

The sub-plot had nine (9)fertilizer Technology plus no fertilizer;

T_1 = Control

T_2 = Cow manure(50g/hill) + Poultry manure (50g/hill)

T_3 = Cow manure(100g/hill)

T_4 = Cow manure(100g/hill)+ Micro-D_DAP(3g/hill)

T_5 = Micro-D_DAP(3g/hill)

T_6 = DAP 41:46:00

T_7 = Poultry manure (150g/hill)

T_8 = Poultry manure (100g/hill)

T_9 = Poultry manure (50g/hill)

T_{10} = Poultry manure (100g/hill) + Micro-D_DAP(3g/hill)

Planting date:

Koutiala-17^{th} June, 2017

10^{th} July, 2018

Bougouni- 08^{th} July,2017

11^{th} July, 2018

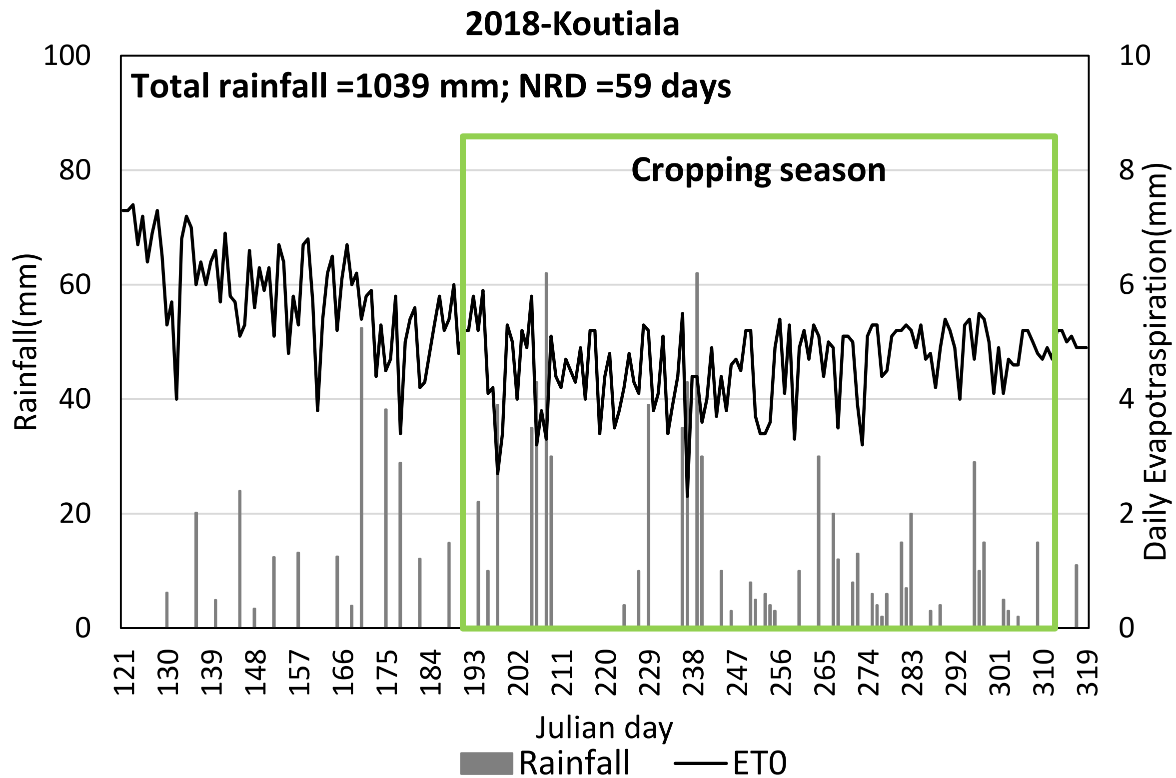
Bamako- 14^{th} June, 2017

7^{th} July, 2018.

Table 1: Physical and chemical properties of the soils (0–15 cm depth) at the three sites

Soil parameters	M'pessoba, Koutiala	Flola, Bougouni	Samanko, Bamako
Sand (%)	55	66.9	67.8
Silt (%)	20	18.1	22.9
Clay (%)	25	15	9.3
Soil texture	**SandyLoam**	**SandyLoam**	**SandyLoam**
pH(H_20)	5.15	6.0	4.6
OC, gkg^{-1}	**1.20**	**5.72**	**2.27**
Total N, gkg^{-1}	**0.14**	**0.53**	**0.21**
Available P, $mgkg^{-1}$	**4.55**	**3.62**	**0.09**
Ca	2.43	1.57	1.4
Mg	0.42	0.42	1
K	0.04	0.08	0.1
Na	0.12	0.09	0.1

Relationship between rainfall and potential evapotranspiration



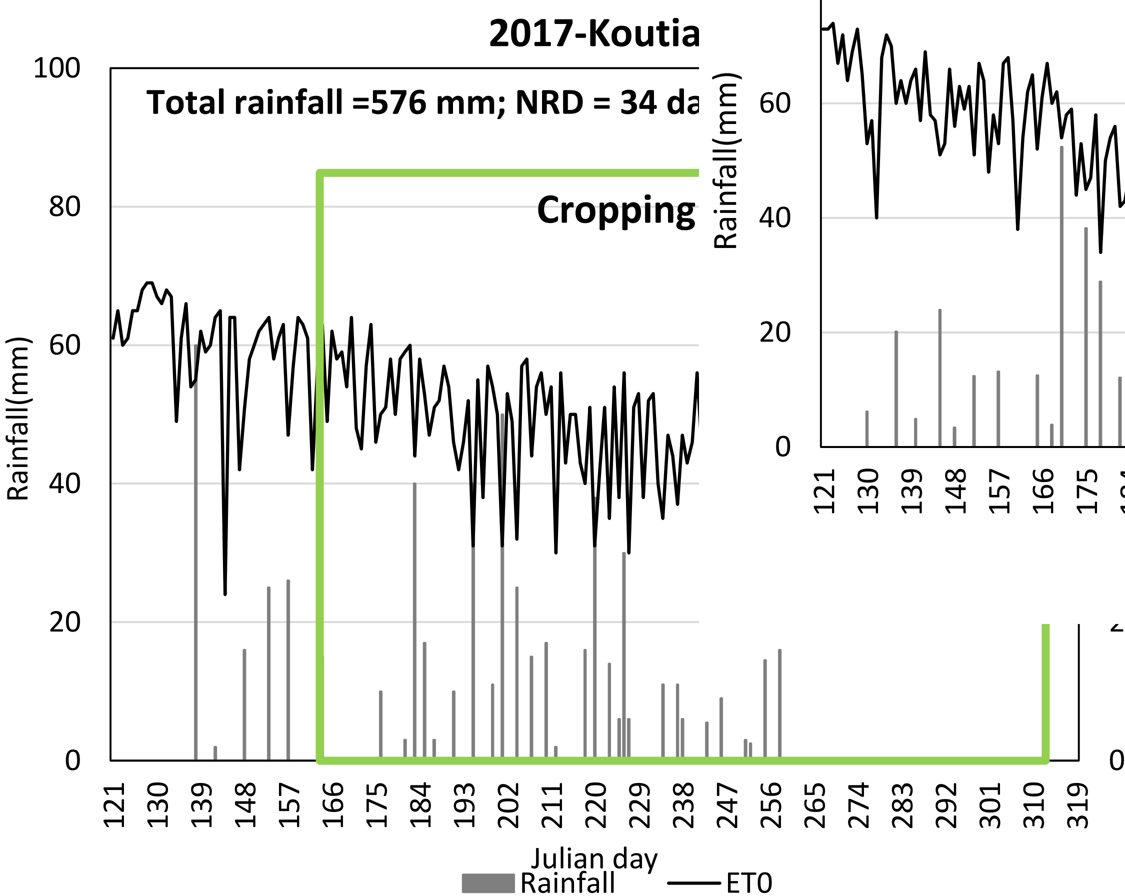
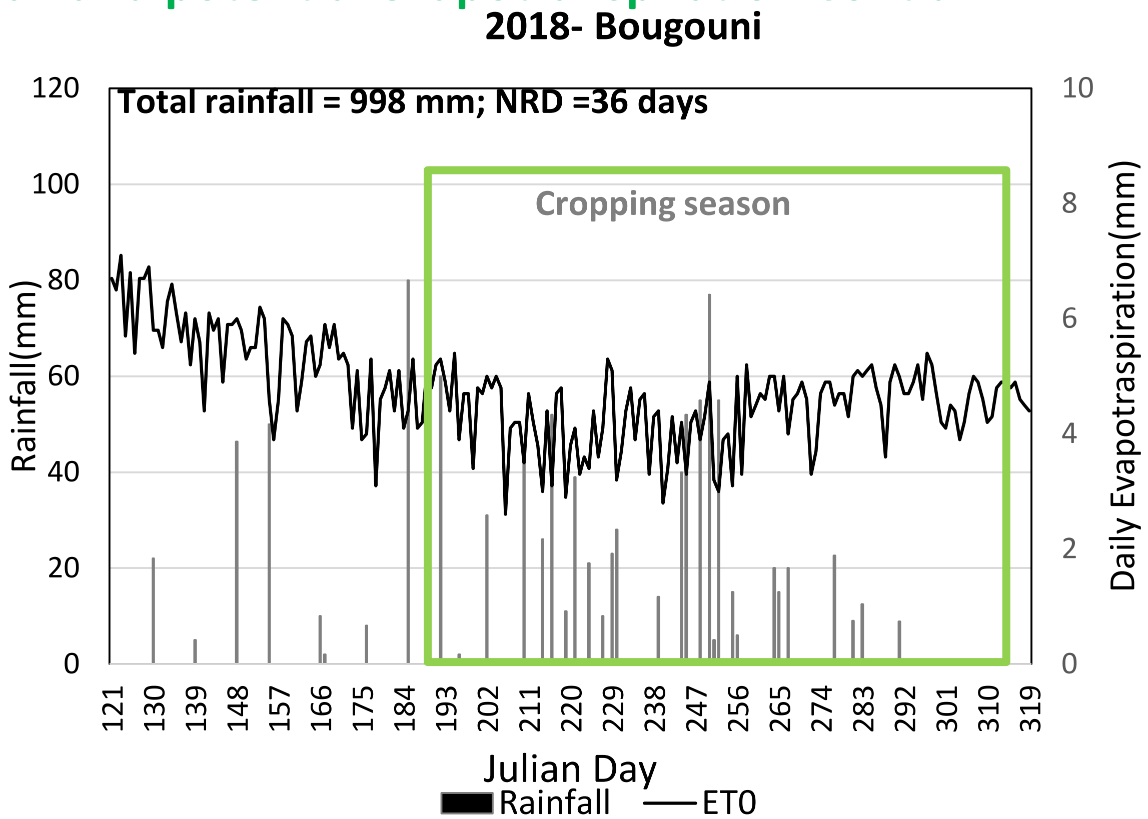


Fig.1a: Daily rainfall and evapotranspiration pattern in 2017 and 2018 growing seasons

Relationship between rainfall and potential evapotranspiration Cont'd



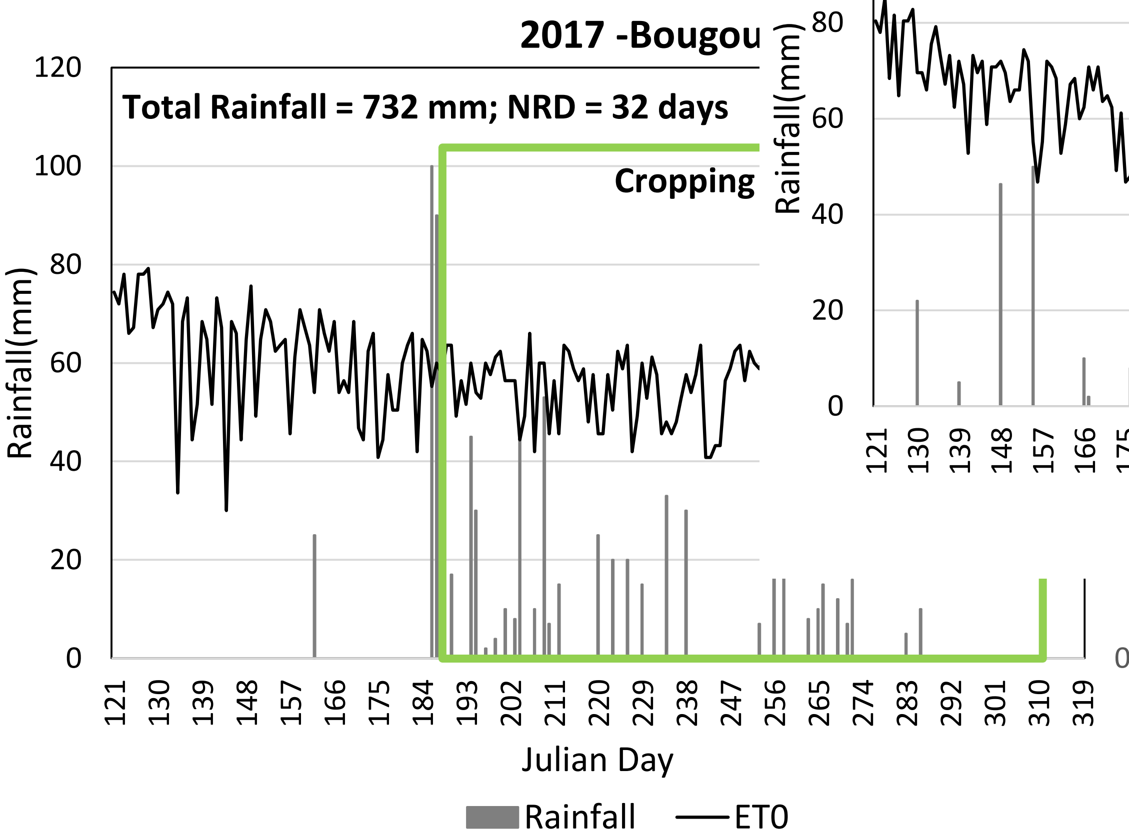
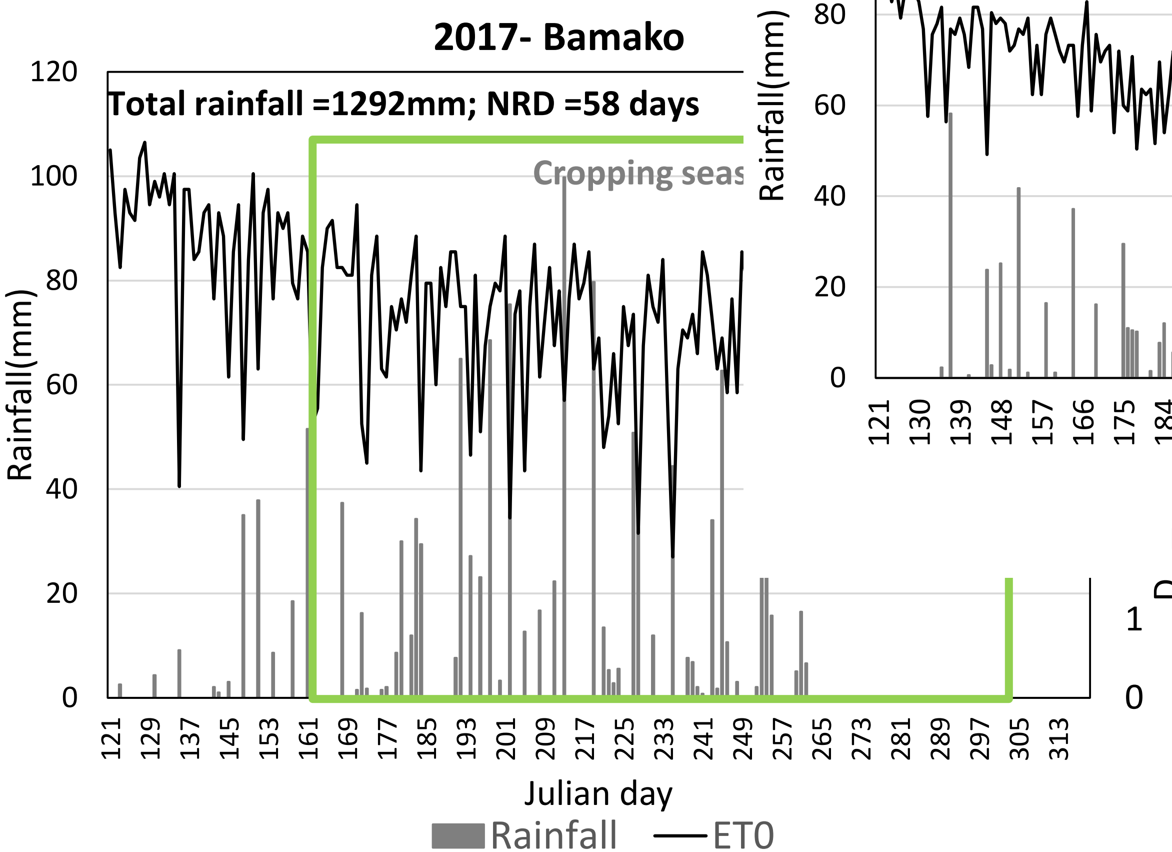


Fig.1b:Daily rainfall and evapotranspiration pattern in 2017 and 2018 growing season

Relationship between rainfall and potential evapotranspiration cont'd



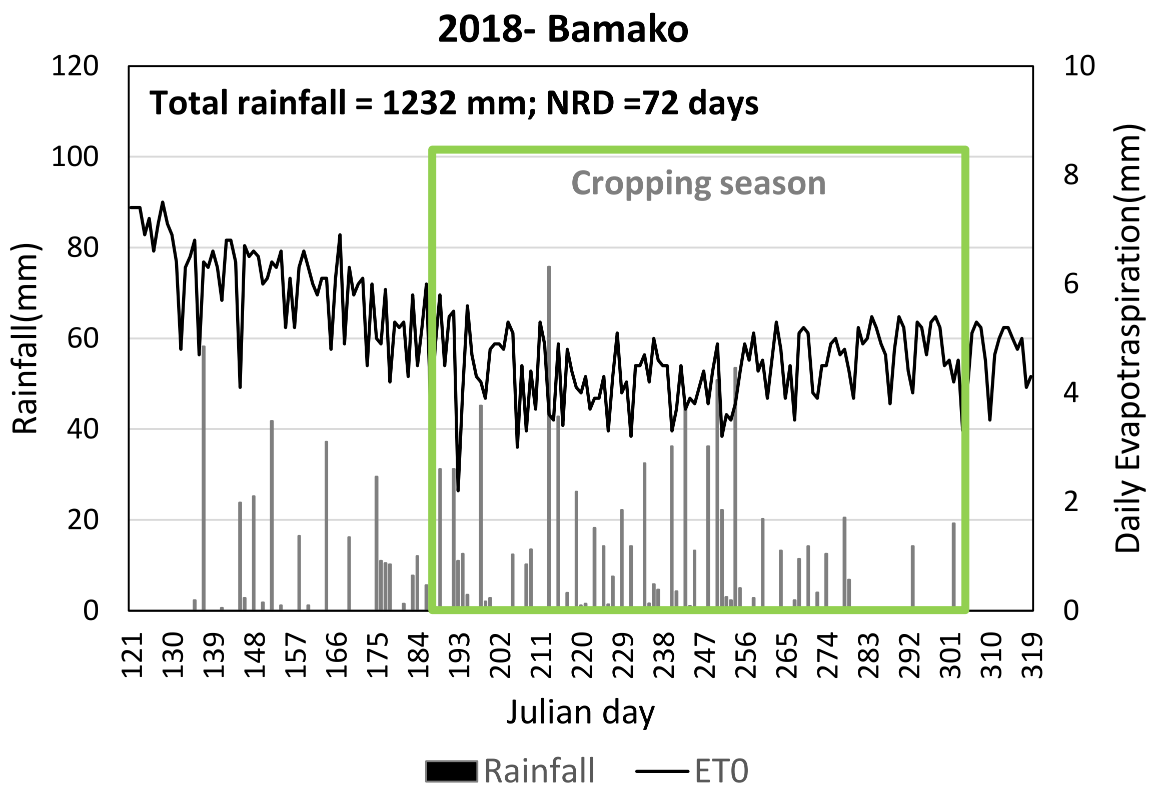


Fig.1c: Daily rainfall and evapotranspiration pattern in 2017 and 2018 growing season

Seasonal effects on Grain yield

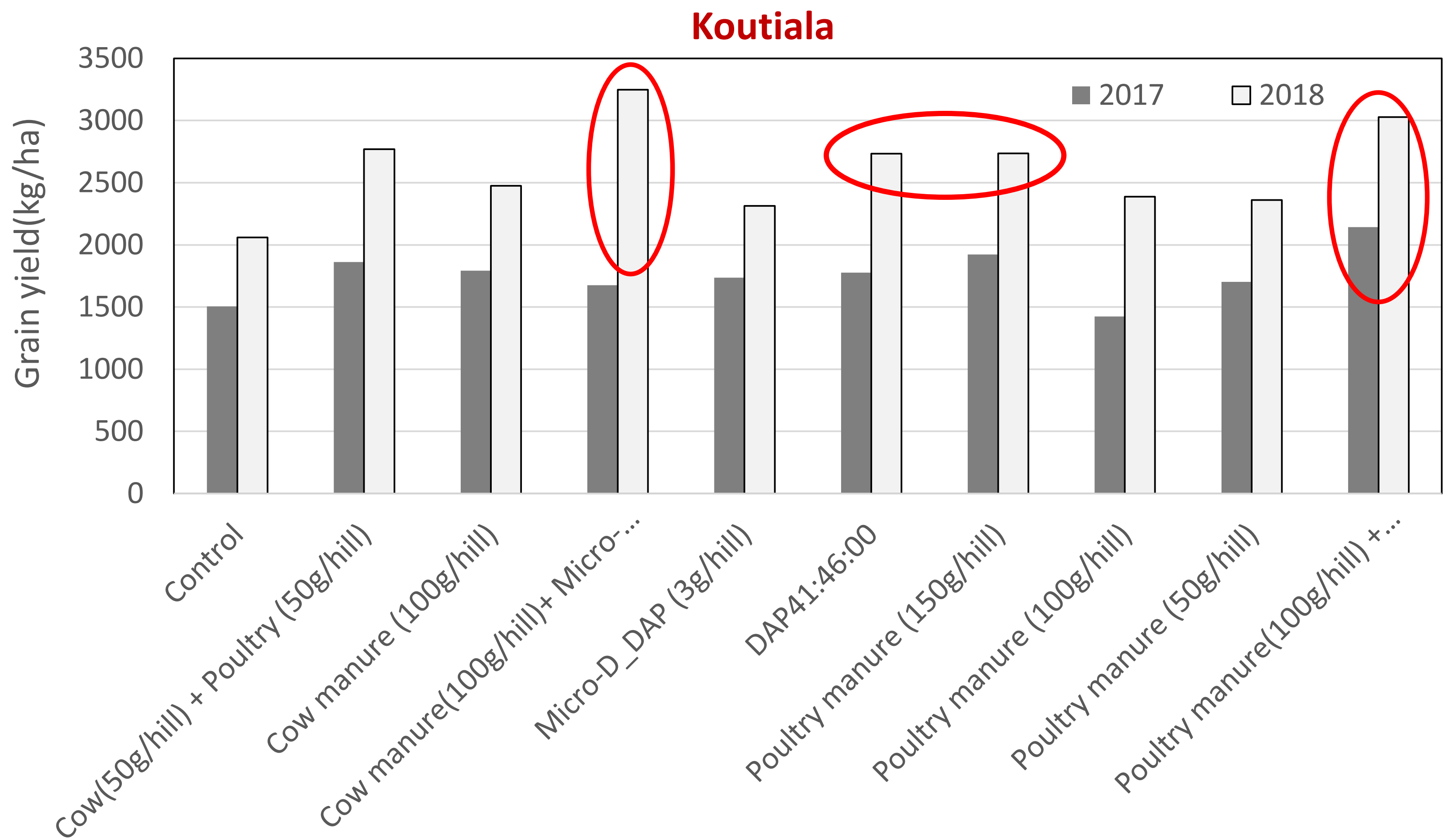


Fig.2a:Performance of the fertilization technology on sorghum production

Seasonal effects on Grain yield

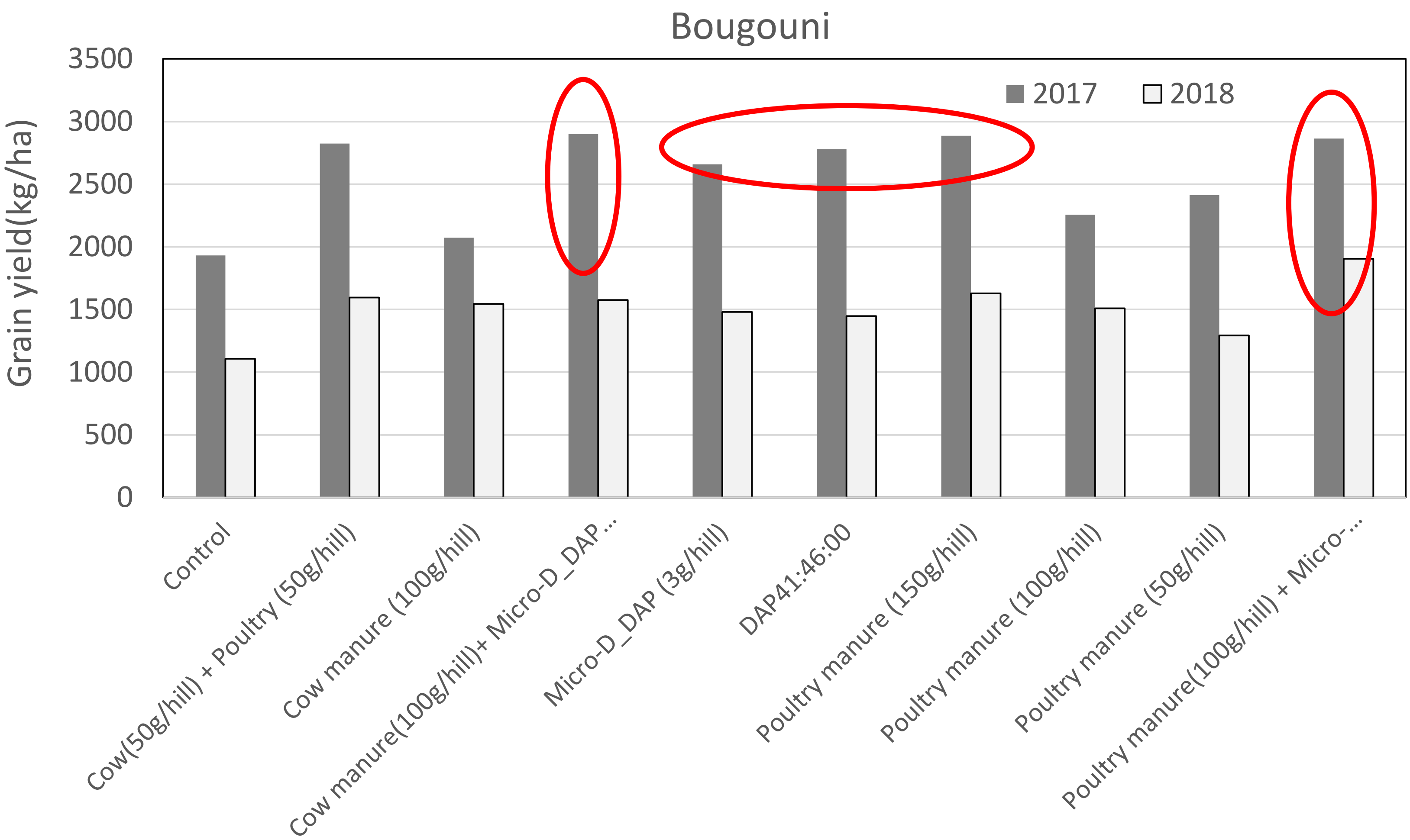


Fig.2b:Performance of the fertilization technology on sorghum production

Seasonal effects on Grain yield

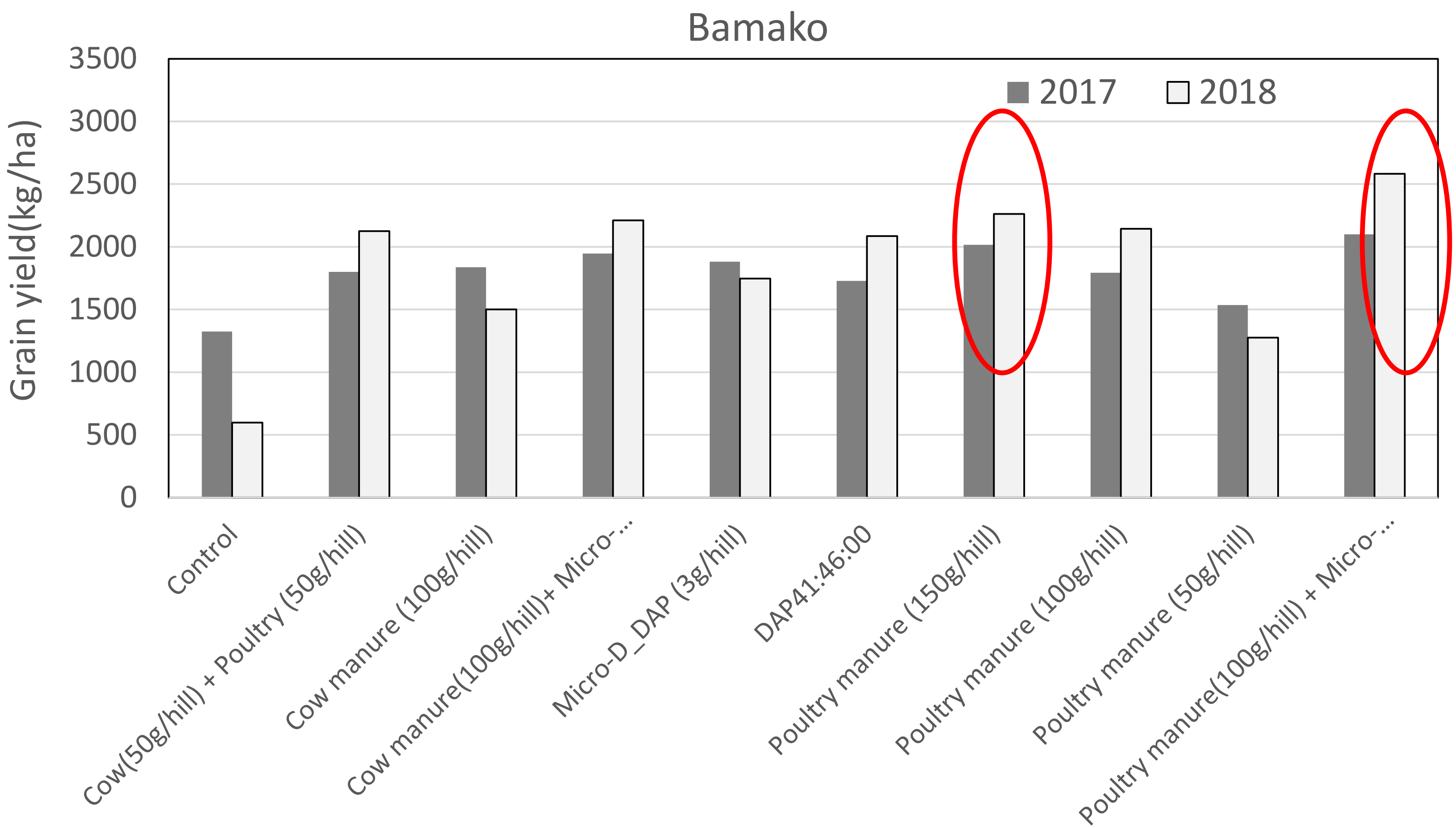


Fig.2c:Performance of the fertilization technology on sorghum production

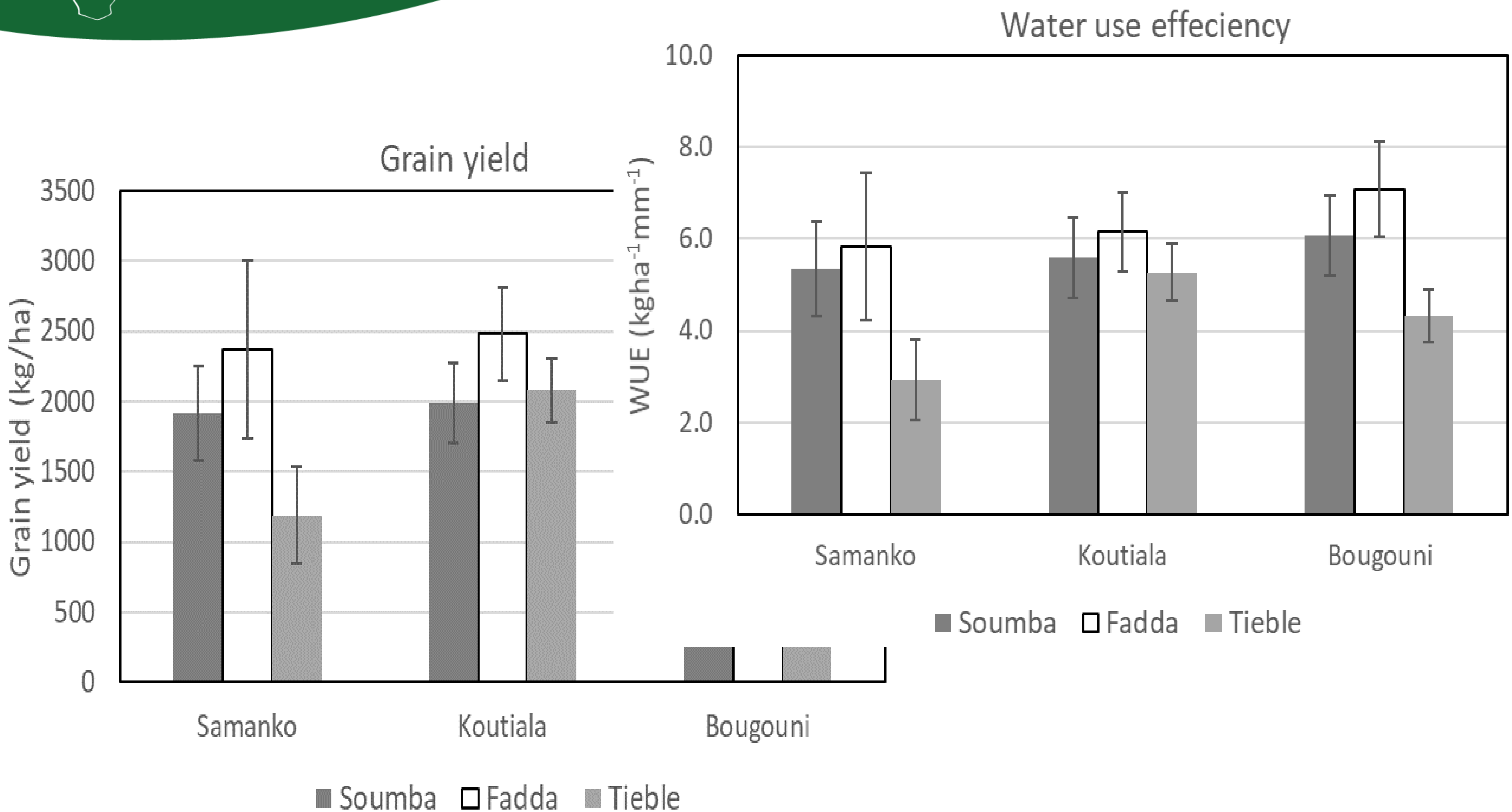


Fig.3: Site effects on grain yield and water use efficiency (WUE) across sorghum varieties *(mean of 2017 and 2018 growing seasons)*

Table 1a: Effect of Fertilization technology on grain yield, Stover yield, Total water use and Water use efficiency

Code	Parameters	Grain yield	Stover Yield	TWU	WUE
	Fertilization (F)	**Koutiala**			
T_1	Control	1782	10979	403	4.5
T_2	Cow(50g/hill) + Poultry (50g/hill)	**2316**	11678	**395**	**6.1**
T_3	Cow manure (100g/hill)	2134	8340	398	5.5
T_4	Cow manure(100g/hill)+ Micro-D_DAP (3g/hill)	**2462**	10666	**395**	**6.6**
T_5	Micro-D_DAP (3g/hill)	2025	9508	399	5.2
T_6	DAP41:46:00	2256	9592	401	5.8
T_7	Poultry manure (150g/hill)	**2329**	11795	**395**	**6.0**
T_8	Poultry manure (100g/hill)	1906	9630	399	5.0
T_9	Poultry manure (50g/hill)	2032	9578	400	5.2
T_{10}	Poultry manure(100g/hill) + Micro-D_DAP(3g/hill	**2586**	11703	**392**	**6.8**
	Mean	**2183**	***11619***	***398***	***5.67***
	LSD of F ($P \leq 0.05$)	395**	3319^{ns}	5.03**	1.07**

Fertilization technology increase grain yield between 10% and 45% against no fertilizer (control)

Table 1b: Effect of Fertilization technology on grain yield, Stover yield, Total water use and Water use efficiency

Code	Parameters	Grain yield	Stover Yield	TWU	WUE
	Fertilization (F)	**Bougouni**			
T_1	Control	1520	7720	345	4.4
T_2	Cow(50g/hill) + Poultry (50g/hill)	**2210**	10230	**350**	**6.3**
T_3	Cow manure (100g/hill)	1810	8489	351	5.2
T_4	Cow manure(100g/hill)+ Micro-D_DAP (3g/hill)	**2240**	10880	**354**	**6.3**
T_5	Micro-D_DAP (3g/hill)	2070	9564	355	5.8
T_6	DAP41:46:00	2114	10421	**342**	**6.2**
T_7	Poultry manure (150g/hill)	**2258**	10890	**346**	**6.5**
T_8	Poultry manure (100g/hill)	1884	8599	346	5.5
T_9	Poultry manure (50g/hill)	1852	8194	345	5.3
T_{10}	Poultry manure(100g/hill) + Micro-D_DAP(3g/hill	**2384**	10248	**353**	**6.8**
	Mean	***2034***	***9524***	***349***	***5.82***
	LSD of F ($P \leq 0.05$)	363**	1816**	12.5^{ns}	1.05**

Fertilization technology increase grain yield between 19% and 57% against no fertilizer (control)

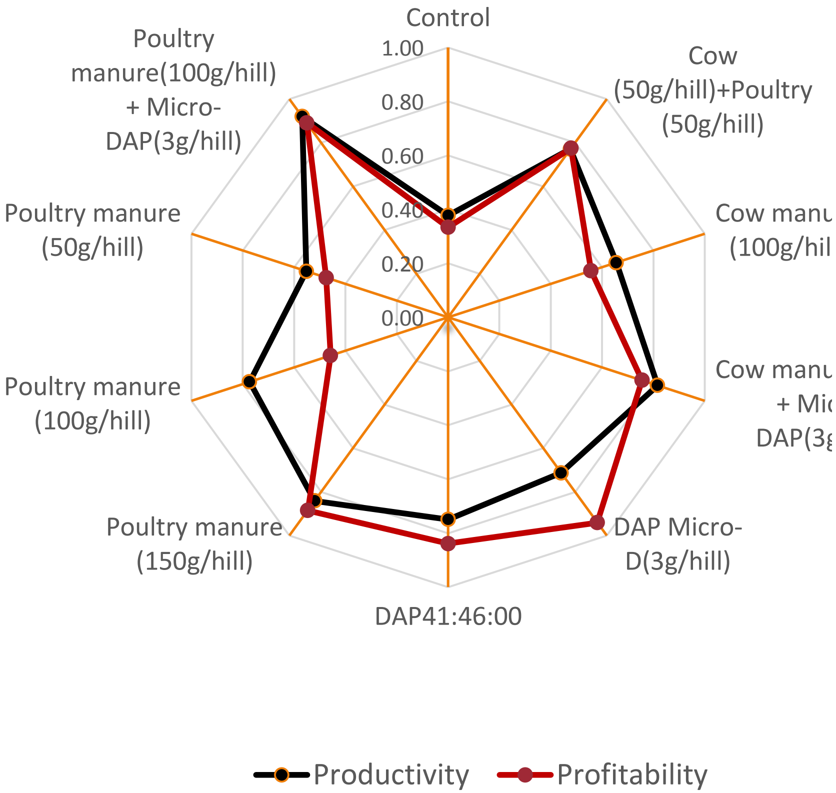
Table 1b: Effect of Fertilization technology on grain yield, Stover yield, Total water use and Water use efficiency

Code	Parameters	Grain yield	Stover Yield	TWU	WUE
	Fertilization (F)		**Samanko**		
T_1	Control	961	3637	404	2.4
T_2	Cow(50g/hill) + Poultry (50g/hill)	1962	6667	395	5.1
T_3	Cow manure (100g/hill)	1669	5454	399	4.2
T_4	Cow manure(100g/hill)+ Micro-D_DAP (3g/hill)	**2078**	7182	**395**	**5.4**
T_5	Micro-D_DAP (3g/hill)	1813	5175	397	4.6
T_6	DAP41:46:00	1906	5110	394	4.9
T_7	Poultry manure (150g/hill)	2140	6488	**393**	**5.6**
T_8	Poultry manure (100g/hill)	**1969**	7138	392	**5.2**
T_9	Poultry manure (50g/hill)	1405	5610	394	3.7
T_{10}	Poultry manure(100g/hill) + Micro-D_DAP(3g/hill	2341	6901	**394**	**6.0**
	Mean	**1824**	**5936**	**396.0**	**4.7**
	LSD of F ($P \leq 0.05$)	450**	1293**	4.38**	1.2**

Fertilization technology increase grain yield between 46% and 144% against no fertilizer (control)

Sustainable Intensification (SI) domain

Trade-off Analysis of the fertilization Technology in Bamako



Trade-off Analysis of the fertilization Technology in Koutiala and Bougouni

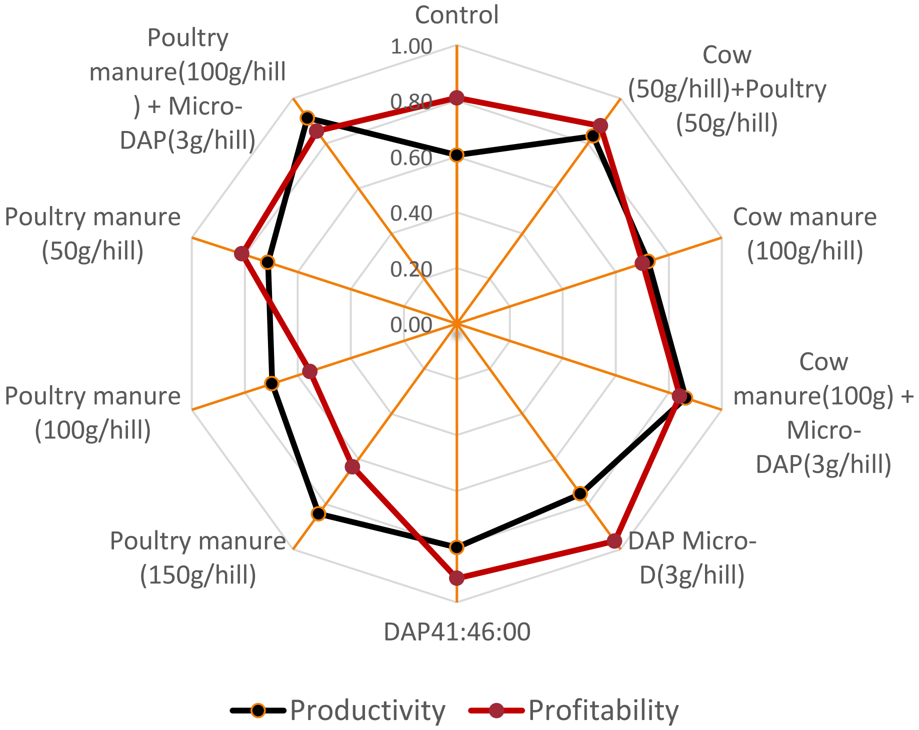


Table 4: Enterprise Decision of Sorghum production under different fertility management in Sudan savanna agroecological zone of Mali(mean of 2017 and 2018 growing seasons)

Site/Treatment	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Koutiala										
Cost of production (CFA/ha)	123,900	235,150	222,789	264,121	165,232	208,530	309,317	247,511	185,706	288,843
Return (CFA/ha)	378,728	492,174	453,398	523,222	430,313	479,424	494,889	405,049	431,729	549,549
Net Income (CFA/ha)	254,828	257,024	230,609	259,101	265,080	270,894	185,572	157,538	246,024	260,705
Benefit cost Ratio	2.1	1.1	1.0	1.0	1.6	1.3	0.6	0.6	1.3	0.9
Break-even yield at current price (kg/ha)	991	1,881	1,782	2,113	1,322	1,668	2,475	1,980	1,486	2,311
Bougouni										
Cost of production (CFA/ha)	123,900	235,150	222,789	264,121	165,232	208,530	309,317	247,511	185,706	288,843
Return (CFA/ha)	323,030	469,566	384,595	475,911	439,905	449,260	479,748	400,267	393,627	506,635
Net Income (CFA/ha)	199,130	234,416	161,807	211,790	274,672	240,730	170,432	152,756	207,921	217,792
Benefit cost Ratio	1.6	1.0	0.7	0.8	1.7	1.2	0.6	0.6	1.1	0.8
Break-even yield at current price (kg/ha)	991	1,881	1,782	2,113	1,322	1,668	2,475	1,980	1,486	2,311
Samanko										
Cost of production (CFA/ha)	127,600	238,850	226,489	267,821	168,932	212,230	251,211	313,017	189,406	292,543
Return (CFA/ha)	204,266	417,014	354,592	441,610	385,351	405,087	454,706	418,351	298,589	497,409
Net Income (CFA/ha)	76,666	178,164	128,103	173,789	216,419	192,857	203,495	105,334	109,184	204,866
Benefit cost Ratio	0.6	0.7	0.6	0.6	1.3	0.9	0.8	0.3	0.6	0.7
Break-even yield at current price (kg/ha)	1,021	1,911	1,812	2,143	1,351	1,698	2,010	2,504	1,515	2,340

T_1 - Control; **T_2** -Cow(50g/hill) + Poultry(50g/hill); **T_3**- Cow manure (100g/hill); **T_4** - Cow manure (100g/hill)+ Micro-D_DAP(3g/hill);**T_5**-Micro-D_DAP (3g/hill); **T_6**- DAP41:46:00; **T_7**-Poultry manure (150g/hill); **T_8**-Poultry manure (100g/hill);**T_9**-Poultry manure (50g/hill);**T_{10}-** Poultry manure (100g/hill)+ Micro-D_DAP(3g/hill)

What next??

Thank You

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